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# The Influence of Various Light Intensity and Natural Feeds to the Growth of Abalone *Haliotis squamata* in Aquaculture System

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## Abstract

**Magdalena Latuihamallo. 2014. The Influence of Various Light Intensity and Natural Feeds to the Growth of Abalone *Haliotis squamata* in Aquaculture System. *Aquacultura Indonesiana, 15 (1) : 32-40.*** Aquaculture technology of abalone is commonly using traditional method in which natural resources are used as the primary inputs. Recent studies however showed that light intensity could also enhance the apetite of abalone despite of food types and concentrations. This study was emphasized at investigating light intensity individually or sinergistically with food types and concentrations in enhance growth rates of abalone. A randomised complete factorial design with three different treatments of light intensities (0 luxes, 250 luxes, and 500 Luxes), two levels of food resources (*Gracillaria licheinodes* and *Ulva fasciata*), and three levels of food percentage (20%, 22.5% and 25%) for three replicates were held. The result showed that light intensity, food types and food concentration significantly affected the growth rates of abalone. Light intensity of 250 luxes with food type of *Ulva fasciata* at the level concentration of 22.5% resulted on the highest growth rate, both at laboratory level and in the field (sea). The highest growth rate of abalone was found in the outdoor system, maximum ages of 8.5 years, maximum length of 114 mm, and maximum weight of 44 g.

***Keywords***: Feed type; Growth pattern; *Haliotis squamata;* Light intensity

## Introduction

Abalone is a kind of gastropod which has high economic value and being a profitable income source to fishers in Indonesia caused by its high price and simple processing. People in several countries are fond of this kind of gastropod caused by its high nutrition, else the abalone doesn't digest the red tide planktons which produced PSP toxins, because abalone graze alga or sea weeds (Sarita and Effendy, 2005).

Abalone *Haliotis squatama* has some comparative benefits compared with other spesies of abalone such as *H. asinina*, like: (a) higher price; (b) better in performance; (c) more be liked by Japanese consumens; (d) higher demands. Even both *Haliotis squatama* and *H. Asinina* has same benefits of its flesh as well as its shell (Fahri, 2009).

Abalone is nocturnal, which having activities in the night and taking rest in the day, or feed in small amounts in the day (Fallu, 1991). Uki (1981) specified in research result that abalone feed in the evening to the middle of night. As a nocturnal, abalone has a reflection layer of pigmen behind the light that accepted by the eyes to the photoreceptor (Ruppert and Barnes, 1994). Lundelius and Freeman (1986) described that the signal of photoreceptor was accepted by the photoreceptor which in the brain ganglion. Then the signal activated neurosecretory in brain ganglion to stimulate the growth of abalone's reproductive organ. Also, was assumed that the proccess happened in abalone feeding habit, where the signal of photoreceptor in brain ganglion accepted this dark condition and stimulate the abalone to eat actively. Photoeriod is a duration of organism daily lighting or the time between sunrise and sunset (Anonymous, 2006).

This study was aimed to analyze the influence of light intensity and natural feeds to the growth of *Haliotis squatama* in aquaculture system.

## Methods

### *Sample of Abalone*

Sample of abalone chosen from spesies *Haliotis squamata* had size ranged between 3.5–4.5 cm about 4050 individuals. Samples divided by five parts, *i.e*: 2430 individuals in laboratory scale (810 individuals in permanent tank, 810 individuals in fibre tank, and 810 individuals in outdoor tank), and 1620 individuals in outdoor laboratory (810 in floating cage method and 810 at long line method). The samples were collected from both nature and culture.

Abalone *H. squamata* with size ranged 3-4 cm about 900 individuals selected from

Perairan Pekutatan Negara Bali were carried to BBRPBL Gondol. The samples were transported using styrofoam and wet sponge, and were packed by considering the management and abalone handling. After the selection, the steps which had to be noticed were handling in tanks, foods management, cultivation, and health management.

### *Data Analysis*

The hypothesis ($H_0$) tested of this research was "the light intensity and type of foods did not influence the growth of abalone *H. squamata* in aquaculture system", and analyzed by using Analysis of Varians (ANOVA) Factorial Design.

### *Growth Rate*

The design was to measure the growth rate of abalone by analyzing the length and weight of abalones in certain time. Weekly growth rate of abalone *H. squamata* was assumed by using formula based on Ricker (1979):

$$DGR = \frac{L_t - L_0}{T}$$

Where :

DGR : weekly growth rate of abalone (µm/week)
Lo : average length of shell in initial time of research (µm)
Lt : average length of shell in the end of research (µm)
T : period of culture time (day)

### *Optimal Growth*

The design to measure the optimal growth of abalone was based on quadratic regression equation, formulated as:

$$y = a + bx + cx^2 + \varepsilon$$

where :

Y = abalone growth
X = percentage of food
a = intercept coefficient
b dan c = regression coefficient
ε = error

### *Survival Rate*

The design to measure the survival rate of abalone using formula based on Effendi (1979):

$$SR = \frac{N_t}{N_0} \times 100\%$$

where :

$SR$ = the survival rate of abalone (%)
$N_t$ = population number at the end of period (individuals)
$N_0$ = population number at the initial time of period (individuals)

## Results

Natural foods usually used in abalone cultivation were species of *Euchema cottonii, Gracillaria arculata*, *Gracilaria gigas*, *Gracilaria solicornia*, *Gracillaria racillariopsis heteroclada*, *Gracillaria verrucosa,* and *Ulva* sp. (Sarita and effendy, 2005). Those species had been tested and influenced the growth rate of abalone (Ikenoue, 1993; Capinpin and Hosoya, 1995). While Cajipe *et al*. (1978), Sarita and Effendy (2005) concluded that *Gracillaria verrucosa* often being used as the natural food of abalone cultivation for its high mineral and amino acid contents which giving a better growth to cultured abalone.

By the measurement of abalones weight, the result showed that culturing using long line with all kind of treatments (type of food, food percentage, and light intensity) were non-significant. It showed that type of food treatment, any percentage of food, and various light intensity did not influence to abalone growth significantly, although increasing the weight comparatively. While the floating cage method with all kind of treatments giving significant result which meant giving the influence to the growth of abalone. This was caused by a better lighting in using floating cage method which affected the abalone feed consumption. This result also answered by the opinion of Fallu (1991) and Uki (1981) which stated that abalone ate at night (from evening to the middle of night). The cultivation in fibre tank resulted high significant value in type of food treatment and food percentage to growth of abalone, while insignificant in light intensity treatment to growth of abalone.

### *Growth Rate*

Result of growth rate calculation from abalone cultured in indoor permanent tank, indoor fibre tank, outdoor fibre tank, floating cage, and longline were 0.0752, 0,03, 0.1818, 0.0653, and 0.0612, respectively. The calculation were done based on light intensity treatment, by the reason of the ANOVA results which the light intensity influenced the most significant. The assumption was the more high the light intensity, the more high the rate.

### *Optimal Growth*

### Indoor Permanent System

Analysis of optimal growth to each individu of abalone cultured in indoor permanent system was held to find the relation between weight and food consumption, by using software program MINITAB 16. It was shown in Figure 1. Regression equation obtained by the result analysis of relation between weight and food consumption was $y$ = 78.19 + 0.2524 $x$ – 0.003416 $x^2$, so optimal growth counted as $x$ = 36.94, or equal to 37 g of abalone weight.

### Indoor Fibre System

Analysis result for optimal growth in indoor fibre system was shown in Figure 2. Regression equation obtained by the result analysis of relation between weight and food consumption was $y$ = 66.21 + 1.806 $x$ – 0.04403 $x^2$, so optimal growth counted as $x$ = 20.51, or equal to 21 g of abalone weight.

### Outdoor System

Analysis result for optimal growth in indoor fibre system was shown in Figure 3. Regression equation obtained by the result analysis of relation between weight and food consumption was $y$ = 69.45 + 1.913 $x$ – 0.02156 $x^2$, so optimal growth counted as $x$ = 44.36, or equal to 44 g of abalone weight.

### Floating Cage System

Analysis result for optimal growth in indoor fibre system was shown in Figure 4. Regression equation obtained by the result analysis of relation between weight and food consumption was $y$ = 66.91 + 3.981 $x$ – 0.1372 $x^2$, so optimal growth counted as $x$ = 14.51, or equal to 15 g of abalone weight.

### Longline System

Analysis result for optimal growth in indoor fibre system was shown in Figure 5. Regression equation obtained by the result analysis of relation between weight and food consumption was $y$ = 14.88 + 0.2973 $x$ – 0.004964 $x^2$, so optimal growth counted as $x$ = 29.95, or equal to 30 g of abalone weight.

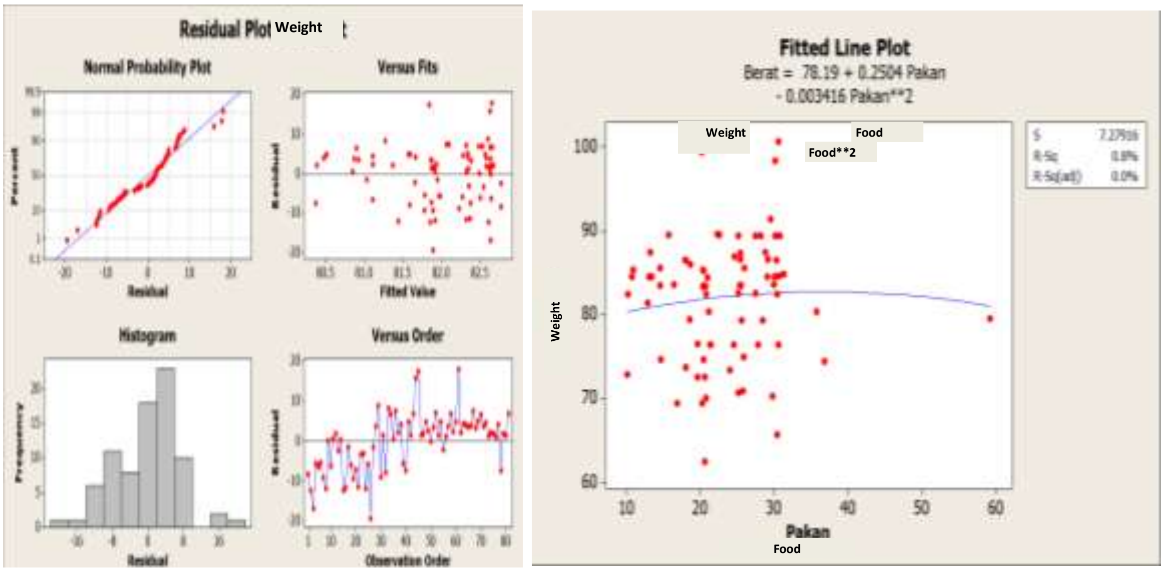


Figure 1. Analysis Result Graphic of Optimum Growth of Abalone Cultured in Indoor Permanent System using MINITAB 16

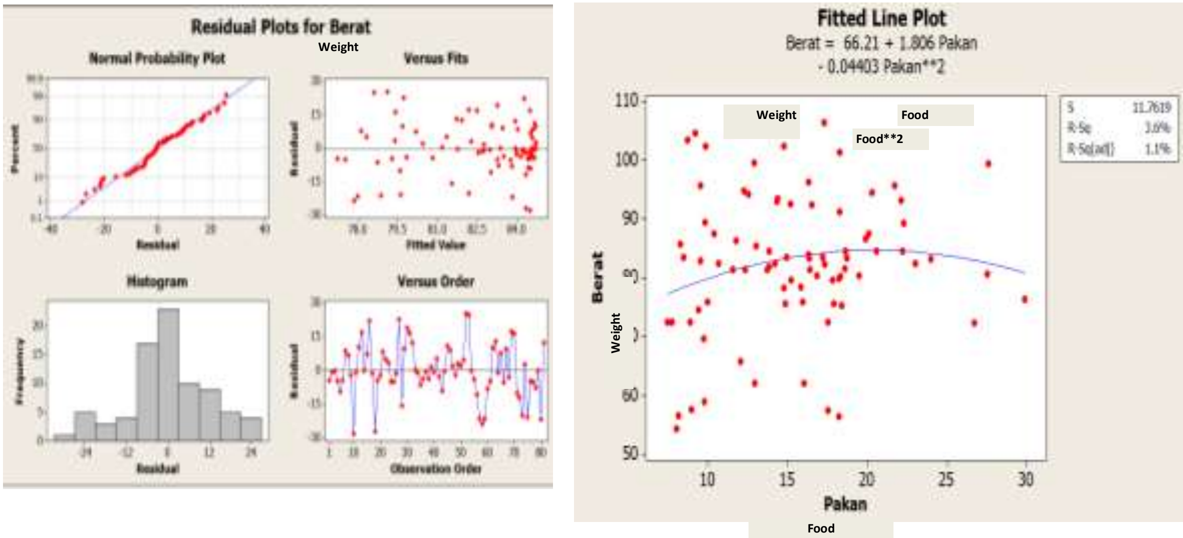


Figure 2. Analysis Result Graphic of Optimum Growth of Abalone Cultured in Indoor Fibre System using MINITAB 16

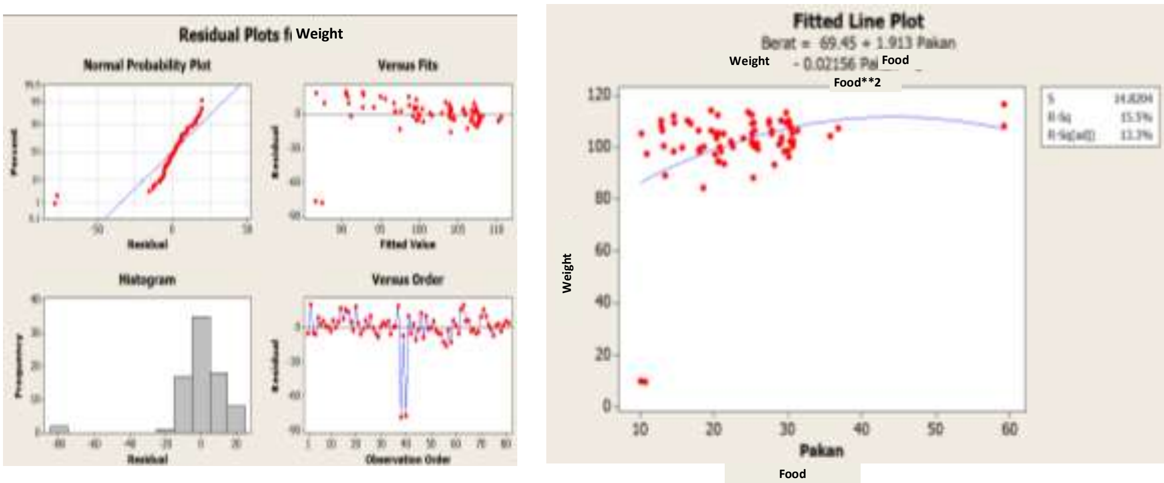


Figure 3. Analysis Result Graphic of Optimum Growth of Abalone Cultured in Outdoor System using MINITAB 16

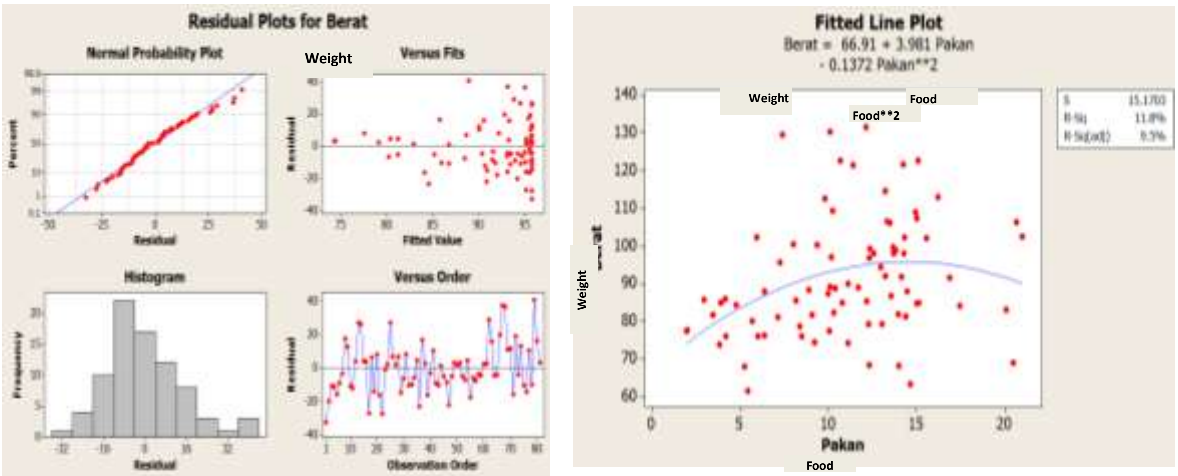


Figure 4. Analysis Result Graphic of Optimum Growth of Abalone Cultured in Floating Cage System using MINITAB 16

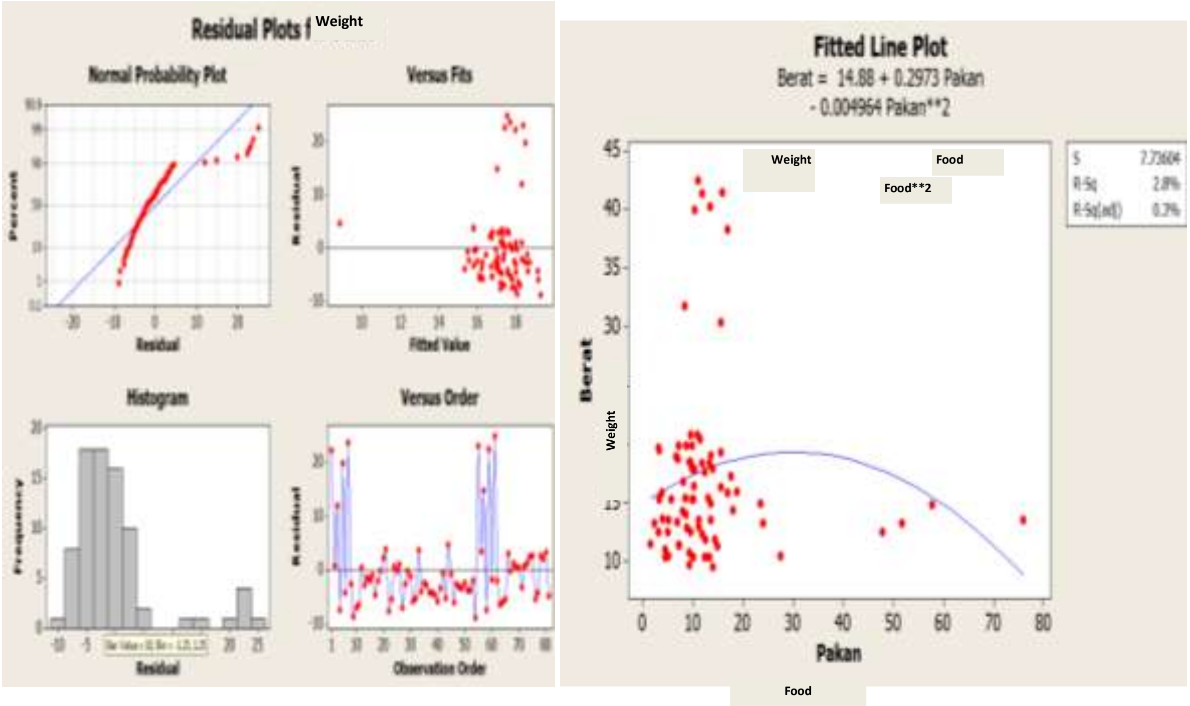


Figure 5. Analysis Result Graphic of Optimum Growth of Abalone Cultured in Longline System using MINITAB 16

## Survival Rate

The survival rate results were 100% to all aquaculture systems, which meant no mortality of abalone during the research. It might be caused by good water quality and handling over the research.

## Discussion

Based on laboratory analysis result, the composition of food nutrients from spesies *E. cottonii* had 5.68% protein and 6.22% carbohydrate and *G. arcuata* had 6.11% protein and 14.80% carbohydrate. While Cajipe *et al*. (1978) stated that *G. verrucosa* contained of 13.85% - 30.59% protein depend on its water and essential amino acid contents (Arginine, Histidine, Lysine, Methionine, Valine, and Phenylalanine) and non-essential amino acid (Alanine, Asam Aspartic, Cystine, Asam Glutamic, Glycine, dan Serine). It showed that *G. verrucosai* had higher protein compared with others. So it would be one of the reason why *G. verrucosa* provided faster influence in gonad growth. Another reason that assumed, *G. verrucosa* was finer in texture and size morphologically compared with other species, causing the preference of the abalone appetite.

Rahmawati *et al.* (2008) stated that alga *Ulva* sp. and *Gracillaria* sp. were better compared to other types of alga used as natural food for abalone culture, which both provided better result. Juveniles of abalone species *Haliotis asinina* fed the red alga *Gracilariopsis heteroclada* and artificial diet showed faster growth in terms of both total body weight and shell length than those fed the red alga *Kappaphycus alvarezii* (Capinpin and Corre, 1996). Capinpin and Corre (1996) also suggested that *Gracillaria* sp. could be used as natural food to stimulate the growth and found to be in proportion as food for abalone culture.

Abalone species *Haliotis asinina* and *H. squamata* preferred alga as their food, however the growth rate was found slow. Priyambodo *et al.* (2005) and Susanto *et al.* (2007) suggested that growth rate of abalone during the culture and fed with alga showed to be slow and heterogeneous (not equal). However, insufficient food availability during the early life stages strongly influences survival and growth of postlarval abalone (Kawamura *et al.*, 1998; Takami *et al.*, 2000; Sasaki and Sheperd, 2001; Roberts *et al.*, 2001), although Onitsuka *et al.* (2008) reported that food limitation was not the only factor affecting the survival of abalone. Sheperd and Steinberg (1992) explained that there are three factors affecting the alga preference of abalone, *i.e.*, metabolites in alga, alga morphological, and the texture. The nutrition also affects the growth stages.

Based on length of shell measurement, the result showed that the cultivation using permanent medium in laboratory insignificantly influenced to the growth of abalone at each kind of treatments. The influence became significant in type of food treatment using fibre tanks both indoor and outdoor system. While by using long line system, the abalone growth was high significant in food percentage and light intensity treatment. It was equal to Padang (2006)'s opinion which concluded that the photoperiod also could affect food consumption rate and its growth.

Based on width of shell measurement, the result showed that the light intensity treatment influenced insignificantly to shell growth at all kind of culture media. The significant influences were only happened in fibre tank at indoor system with food percentage treatment, and in floating cage with type of food treatment. While the long line media was giving high significant influence with both type of food and food percentage treatment.

Adult and juvenile *Haliotis* spp. Mainly teed at night (Ino, 1943; Sakai, 1962; Uki, 1981) and grow better when cultured in the dark (Ebert and Houk, 1984). While the post-larval abalone cultured in the dark grew as well as those grown in the light (Koike, 2004). Velez-Espino (1999) also found that there was no evidence of nocturnal feeding habit in postlarvae.

The analysis results of ANOVA factorial design were tested to growth data (length, width, and weight) of each individu of abalone cultured in permanent indoor, indoor fibre, outdoor fibre, floating cage, and long line system (Table 1). The result showed that both type of food treatment and food percentage treatment affected the growth of abalone in both permanent system and indoor fibre. While in floating cage system, both factors were significant at the 5% significance level, which meant that if floating cage method was compared to longline system or outdoor tanks, the type of food and the food percentage treatment significantly influences the growth of abalone. Then at Table 1, showed that the type of food and the food percentage more significantly influenced to abalone shell growth both in length or width.

The calculation result of growth rate showed that the highest rate was in outdoor fibre tank treatment (0.1818) while the lowest was in indoor fibre tank treatment (0.03). In outdoor fibre tank, the abalone could reach the maximal length 69 mm in 1.4 years. While in indoor fibre tank, the abalone reached the same length needed longer time (5.2 years). It meant the more high the rate the more short the life time of abalone.

The calculation result of optimal weight obtained by each individu of abalone cultured in outdoor system with feeding treatment (Figure 1-5) showed that abalone would gain optimum weight of 112 g if it was fed about 44 g of food, or equal to 2.5 times of food weight that had been consumed. With this condition, the abalone cultured in this system could gain maximum age of 1.8 year and maximum length of 71 mm compared to maximum length that could be gained by other species. So it could be assumed that the optimum weight gained in this research was in normal range. It was caused by the controllable outdoor system. In simple way, the growth could be formulated as length and weight increasing in some certain times.

The abalone could be cultured in net floating cage or in controlled tank, however the best increasing of the length of abalone shell was those cultured in net floating cage (Susanto *et al.*, 2009). Gallardo and Saloyo (2003) suggested that abalone were cultured in net floating cage with modular system and using seed sized of shell 5.6 cm and weight 50 g over 9 months. While Anonymous (2000) suggested that abalone sized of shell 30 mm with density of 60-100 individu/$m^2$ could reach consumption size (50-60 mm) in 8-10 months. The growth of abalone was slow and different among species, with the rate was about 1.0-2.5 mm/months (Stickney, 2000). The observation held by BBRPBL Gondol suggested the growth of abalone *H. squamata* in terms of the length and width were relatively faster which could reach 5.81 mm and 4.01 mm in 70 days, with the growth rate were about 2.0-2.37 mm per month (Priyambodo *et al.,* 2005; Susanto *et al.,* 2007).

Table 1. Recapitulation of Research Result of Dimension and Weight Increasing of Abalone *H. squamata* in culture systems

| **Weight of Abalone** | | | | | |
|---|---|---|---|---|---|
| **Treatments** | **Culture Systems** | | | | |
| | **P** | **F** | **O** | **K** | **L** |
| Type of Food | $1.89_a$ | $8.84_b$ | $3.18_b$ | $4.05_b$ | $1.55_a$ |
| Food Percentage | $1.84_a$ | $2.54_a$ | $1.76_a$ | $3.70_b$ | $0.68_a$ |
| Light Intensity | $48.26_b$ | $27.31_b$ | $0.57_a$ | $3.49_b$ | $1.27_a$ |
| **Interaction of treatments** | | | | | |
| Type of food *Food Percentage | $0.23_a$ | $6.80_{ab}$ | $0.58_a$ | $4.64_b$ | $0.54_a$ |
| Type of Food *Light Intensity | $0.21_a$ | $1.28_a$ | 0.82a | $1.55_a$ | $0.28_a$ |
| Light Intensity *Food Percentage | $0.09_a$ | $5.08_b$ | $1.23_a$ | $0.35_a$ | $1.66_a$ |
| Type of Food * Food Percentage *Light Intensity | $0.32_a$ | $7.04_b$ | $1.39_a$ | $1.18_a$ | $2.52_b$ |
| **Length of Abalone Shell** | | | | | |
| **Treatments** | **Culture Systems** | | | | |
| | **P** | **F** | **O** | **K** | **L** |
| Type of Food | $0.70_a$ | $4.67_b$ | $4.52_b$ | $0.07_a$ | $0.59_a$ |
| Food Percentage | $0.26_a$ | $1.05_a$ | $1.22_a$ | $0.69_a$ | $5.54_b$ |
| Light Intensity | $2.19_a$ | $136.69_b$ | $514.15_b$ | $54.89_b$ | $14.50_b$ |
| **Interaction of treatments** | | | | | |
| Type of food *Food Percentage | $0.23_a$ | $5.89_b$ | $1.66_a$ | $0.82_a$ | $1.10_a$ |
| Type of Food *Light Intensity | $0.21_a$ | $0.72_a$ | $0.41_a$ | $0.82_a$ | $1.24_a$ |
| Light Intensity * Food Percentage | $0.09_a$ | $4.88_b$ | $0.72_a$ | $0.90_a$ | $2.57_b$ |
| Type of Food * Food Percentage *Light Intensity | $0.32_a$ | $0.22_a$ | $0.87_a$ | $0.79_a$ | $3.15_b$ |
| **Width of Abalone Shell** | | | | | |
| **Treatments** | **Culture Systems** | | | | |
| | **P** | **F** | **O** | **K** | **L** |
| Type of Food | $0.03_a$ | $0.35_a$ | $0.48_a$ | $3.84_b$ | $7.93_b$ |
| Food Percentage | $1.23_a$ | $0.77_a$ | $1.18_a$ | $1.12_a$ | $1.77_a$ |
| Light Intensity | $2.54_a$ | $3.38_b$ | $19.33_b$ | $12.14_c$ | $9.15_b$ |
| **Interaction of treatments** | | | | | |
| Type of food *Food Percentage | $0.61_a$ | $0.81_a$ | $0.70_a$ | $0.91_a$ | $2.28_a$ |
| Type of Food *Light Intensity | $0.86_a$ | $1.08_a$ | $0.44_a$ | $0.57_a$ | $1.58_a$ |
| Light Intensity * Food Percentage | $0.68_a$ | $0.43_a$ | $1.07_a$ | $0.58_a$ | $0.72_a$ |
| Type of Food * Food Percentage *Light Intensity | $0.73_a$ | $0.97_a$ | $1.18_a$ | $0.53_a$ | $1.26_a$ |

where:

P = Indoor permanent tank
F = Indoor fibre tank
O = Outdoor laboratory
K = Floating cage
L = Longline method
a = Non-Significant
b = Significant


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